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# SPECIFICATIONS

FOR

A THREE-CYLINDER, HORIZONTAL, BACK-ACTING

# COMPOUND SCREW ENGINE,

FOR EACH OF THE

U. S. STEAMERS BOSTON AND ATLANTA;

INCLUDING

BOILERS, AIR AND CIRCULATING PUMPS, BLOWERS AND ENGINES, AND ALL THE APPENDAGES AND APPURTENANCES COMPLETE, TOGETHER WITH A LIST OF THE DUPLICATE PIECES, AND OIL-TANKS BE FURNISHED.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1883.

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U. S Navy Steam Engr.

WASHINGTON:
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# SPECIFICATION

FOR A

THREE-CYLINDER, HORIZONTAL, BACK-ACTING

# COMPOUND SCREW ENGINE

**OF 3,500 INDICATED HORSE-POWER.**

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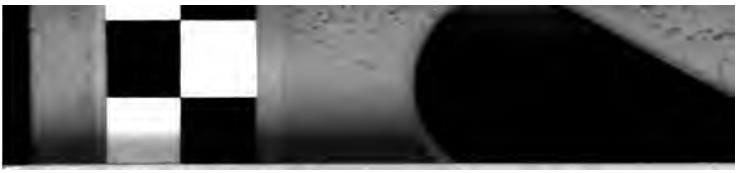
## GENERAL DESCRIPTION.

The engine is to have one high-pressure cylinder of 54 inches diameter and two low-pressure cylinders of 74 inches diameter, and each to have a piston stroke of forty-two inches; the cylinders will be placed on the starboard side of the ship, with their axes parallel to each other, and 9 feet 6 inches apart. Each cylinder will be steam-jacketed and provided with two main valves and two expansion valves, the latter adjustable while the engine is in motion, to cut off between the limits of one-eighth and five-eighths of the stroke of the piston.

The main slide valves are to be worked by means of eccentrics and Stephenson links acting through arms and rock-shafts. The expansion valves are to be operated by means of separate eccentrics; the high-pressure exhaust will connect with the low-pressure cylinders, so as to pass the steam direct to the steam-chests; it will also be arranged to discharge into the condensers, and the low-pressure steam-chests will be fitted with the requisite pipes for admitting the steam direct from the boilers or for exhausting the steam direct into the atmosphere. The high-pressure piston is to have one piston-rod secured to a cross-tail, which is to be coupled by four side rods and two other side-rods to the





cross-head. The low-pressure pistons are to have two rods coupled directly to the cross-heads; the latter are to be mounted on sleds which are to run in troughs recessed in the pump-chests. The connecting rods will be made with caps secured by steel bolts.

The crank-shaft is to be made in three separate interchangeable sections, and secured to each other and the line-shafting by couplings forged on shafts; the cranks for low-pressure cylinders to be placed at an angle of 90° to each other, and that for the high-pressure cylinder to be set intermediate between the others, at angles of 135° with them.

Each section of crank-shaft is to be mounted on two journals. The crank-shaft pillow-blocks are to be trussed from the cylinders by stay-rods secured in brackets projecting from them.

There are to be two air and two circulating pumps, one of each coupled together, and placed directly opposite the low-pressure cylinders; the pump-chests will contain the valve-chambers and channel-ways, and form supports for the condensers. The pumps are to be horizontal, double-acting and arranged to work independently, or in connection with the main engine. Each couple when working independently will be operated through arms and a rock-shaft by a horizontal direct-acting engine placed opposite the high-pressure cylinder.

There are to be two condensers placed above the air and circulating pumps; each will have a cooling surface of 4,000 square feet.

The reversing-cylinder will be placed between the high and after low-pressure cylinders and will act upon a rock-shaft which will connect with the several links.

The platform with the requisite gear for working the engine will be placed between the condensers above the cross-head of high-pressure cylinder; there will be suitable and convenient approaches to it from the deck, quarters, and lower platform leading to the fire-room and shaft-alley.

There are to be eight boilers, divided into two groups, with fire-rooms fore and aft between them, and two smoke-pipes. The boilers will be 11 feet 8 inches in external di-

ameter and 9 feet 9 inches long, and will contain an aggregate of sixteen furnaces, 400 square feet of grate, and 10,064 square feet of heating-surface. They are to work under a pressure of 90 pounds per square inch.

There are to be three compartment pumps, two in the engine-room and one in the forward fire-room, each capable of discharging 1,000 gallons per minute; two boiler feed-pumps with water-pistons 7 inches in diameter and 12 inches stroke, one in each fire-room; also one other pump, for the distiller.

There will be four blowers, two in each fire-room, and each capable of supplying 12,000 cubic feet of air per minute under a water pressure of 1 inch.

The propeller will be of steel, with adjustable blades; its diameter will be 17 feet, and its mean pitch 20 feet, or of such design as may be approved by the Naval Advisory Board.

## DETAILED DESCRIPTION OF ENGINES, SHAFTING, SCREW-PROPELLER, BOILERS, PUMPS, ETC.

### CYLINDER-CASINGS.

The cylinder-casings, which will include the steam and exhaust-ports and passages, inboard heads, bosses and brackets for stay-rods, sole-plates and flanges for cylinder covers and valve-chests, etc., are to be of cast-iron. The casing for high-pressure cylinder is to be 60 inches in diameter inside, and $1\frac{3}{8}$ inch thick; those for the low-pressure cylinders are to be 80 inches in inside diameter, and $1\frac{1}{2}$ inch thick. They will each be fitted with linings which will inclose an annular space of $1\frac{1}{2}$ inch and a stuffing-box at the outboard ends 8 inches in depth.

### CYLINDER-LININGS.

The linings are to be of the best iron, cast as hard as can be worked by tools; they will be $1\frac{1}{2}$ inch thick, and made with flanges $1\frac{1}{2}$ inch wide, which are to be turned and faced, and accurately fitted into the casings as shown in the drawings. They will be smoothly bored to their respective diameters of 54 and 74 inches.

### CYLINDER-HEADS.

The cylinder-heads are to be made with double shells 1 inch thick, and amply stiffened by ribs 1 inch thick. They will have suitable openings cored in, and accurately bored and faced to receive the piston-rod stuffing-boxes; man-holes will also be cored in, bored and faced to receive the man-hole plates.

### CYLINDER-COVERS.

The covers are to be made of the very best cast-iron, with double shells 1 inch thick and well stiffened by ribs 1 inch thick, and to have faced flanges 5 inches wide and 2

inches thick. Openings for man-holes to be cored in, bored and faced for the man-hole plates. The covers are to be finished on the outside; they will be secured in place and to flanges 2¼ inches thick by wrought-iron bolts 1½ inch in diameter with finished nuts; bolts to be spaced not over 6 inches apart.

MAN-HOLES AND PLATES.

The man-holes are to be 15 inches in diameter and closed with double shell plates finished on the outside; they are to have faced flanges 3 inches wide and 1⅜ inch thick, secured in place with wrought-iron bolts 1¼ inch in diameter, spaced not over 6 inches apart.

STEAM AND EXHAUST-PORTS.

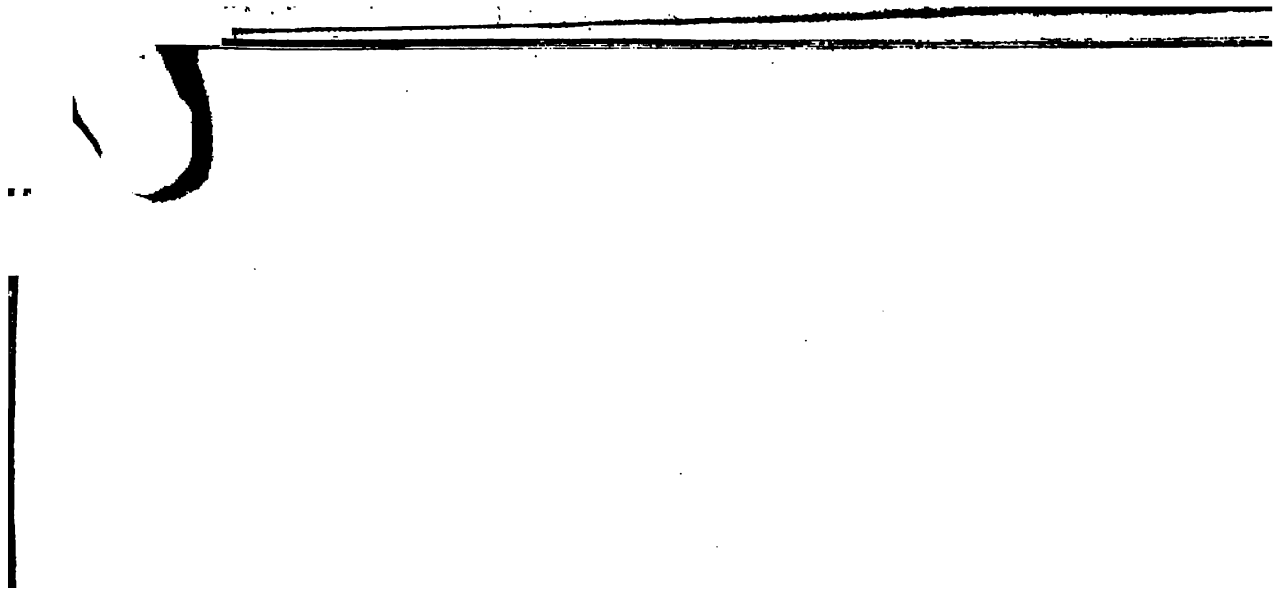
The steam and exhaust-ports for high and low-pressure cylinders are to be double and in two divisions; those for the high-pressure cylinder are to be 2¼ inches wide and 24 inches long, or of a combined area through openings of 216 square inches; those for the low-pressure cylinders are to be 2 inches wide and 33½ inches long, or of a combined area of 268 square inches. Each cylinder is to be provided with ports for starting-valves, which are to be not less than 9 inches in area.

RELIEF-VALVES.

The cylinders are to have a port at each end at the bottom, not less than 15 inches in area, for relief-valves.

BRACKETS FOR STAY-RODS.

The brackets for stay-rods will project from the heads of cylinders; they will be formed by two bosses 14 inches in diameter, and a central web 2 inches thick, and flanges 12 inches wide and 2 inches thick bounding the same, and extending 29 inches above and below the center lines of the cylinders, and will terminate in the pillow-blocks for valve rock-shafts and reversing-shafts. The brackets will have pockets for the stay-rod nuts, which will be 7 inches deep.



SOLE-PLATES.

The cylinders will rest upon legs cast on them, with sole-plates faced 21 inches wide and $2\frac{1}{2}$ inches thick, well ribbed to the webs of the legs, which are to be $1\frac{1}{2}$ inch thick; the holes for the holding-down bolts to have facings $\frac{1}{2}$ inch thick. The distance from center of cylinders to face of sole-plates to be 3 feet 10 inches.

VALVE-SEATS.

The valve-seats are to be made of cast iron of the best quality and as hard as can be worked; they are to be $1\frac{1}{2}$ inch thick and secured in place with composition countersunk screws $\frac{7}{8}$ inch in diameter.

VALVE-CHESTS.

The valve-chests are to be cast with walls 1 inch thick and flanges faced 2 inches thick and $4\frac{1}{2}$ inches wide, all to be well ribbed. Each chest will have two covers and a central web and flanges for sustaining them. The chests will be secured in place by bolts $1\frac{1}{4}$ inch in diameter, spaced not over $5\frac{1}{2}$ inches apart. The chest for the high-pressure cylinder will be made with an opening 16 inches in diameter, in the outboard end, with faced flanges 3 inches wide for the throttle and stop-valves. The chests will have openings through the inboard ends with faced flanges 3 inches wide for the valve-stem stuffing-boxes.

VALVE-CHEST COVERS.

Each valve-chest will have two covers, made of the best iron, cast with double shells 1 inch thick; well ribbed and finished on the outside, except in the panels. The flanges are to be $1\frac{3}{4}$ inch thick and $4\frac{1}{2}$ inches wide. The covers will be secured in place by bolts $1\frac{3}{8}$ inch in diameter, spaced not over 6 inches apart.

MAIN SLIDE-VALVES.

There are to be two main slide-valves for each cylinder, each to be double-ported; those for the high-pressure cylin-

der to have steam-ports 2 inches wide and exhaust-ports $2\frac{1}{4}$ inches wide, all 24 inches long; the valves to have a throw of $2\frac{1}{2}$ inches. The valves for the low-pressure cylinder are to have steam-ports $1\frac{1}{2}$ inch wide and exhaust-ports 2 inches wide, all $33\frac{1}{2}$ inches long, and to have a throw of 3 inches. The valves are to be of the best cast iron, the walls to be $\frac{3}{4}$ inch thick, the lower faces $1\frac{1}{4}$ inch thick, and the upper faces $1\frac{1}{8}$ inch thick.

### CUT-OFF VALVES.

The cut-off valves are to work on the backs of the main slide valves; they are to be of cast iron $\frac{7}{8}$ inch thick, well ribbed, and fitted with pockets for the valve-stem nuts; they will have a throw of 3 inches.

### VALVE-STEMS.

The valve-stems are to be of steel, those for the main valves to be $2\frac{3}{4}$ inches in diameter; the cut-off stems to be $2\frac{1}{8}$ inches in diameter. They will be secured with composition nuts accurately fitted in the pockets of the valves, and by finished wrought-iron nuts to the cross-heads referred to below; they are to be $30\frac{1}{2}$ inches between centers for high-pressure valves, and 40 inches between centers for low-pressure valves.

### VALVE-STEM STUFFING-BOXES.

The stuffing-boxes are to be of composition, each with an annular packing-space of $\frac{5}{8}$ inch and 11 inches deep; they are to be fitted with screw-followers, and packing of an approved kind, adjustable by worm-screws with handles, accessible while the engine is in motion.

### MAIN-PISTONS.

Each cylinder is to be fitted with a composition piston, the shell and ribs of which are to be $\frac{1}{2}$ inch thick, the rims to be $\frac{7}{8}$ inch thick, and the metal around the eyes to be $2\frac{1}{2}$ inches thick for the high-pressure and 2 inches for the low-

pressure rods. The pistons are to be fitted with cast-iron double packing-rings, 6 inches wide and ½ inch thick, and an inner ring 12 inches wide and ⅝ inch thick, all adjusted by steel springs of the proper tension. One-third of the circumference of each piston at the bottom will be fitted with a chock for taking its weight. The followers are to be of composition 1¾ inch thick, and secured in place with wrought-iron bolts 1½ inch in diameter, placed not over 14 inches apart.

PISTON-RODS.

The high-pressure piston-rod is to be of steel, finished 8 inches in diameter, and is to be made with a collar 12 inches in diameter by 2 inches thick, which is to be recessed into the piston; it will be secured to piston by a closed composition collar-nut recessed 2 inches, and to cross-tail by composition collar recessed nuts, which are to be confined by retaining-screws of steel. The low-pressure piston-rods are to be of steel of the best quality, finished all over; they are to be 6¼ inches in diameter and secured in pistons by composition nuts, and to the cross-heads by collars on the rods, and by composition nuts fitted in the same manner as those for the high-pressure side-rods; the lower piston-rods will be fitted with lugs for the air and circulating-pump connections; they are to be 43½ inches between centers horizontally, and 27 inches between centers vertically.

PISTON-ROD STUFFING-BOXES.

The piston-rod stuffing-boxes are to be of composition, each fitted with gland, screw-follower, and adjusting worm-screw; they will have an annular packing-space of 1 inch, and 12 inches deep for high-pressure cylinder, and 16 inches deep for low-pressure cylinders. They will have flanges faced 3 inches wide and 1 inch thick, and each secured by not less than six bolts 1 inch in diameter, and will be fitted with packing of an approved kind.

SIDE-RODS.

For the high-pressure piston-rods there are to be four side-rods, which will connect the cross-tail and two other

side-rods with the cross-heads; all to be secured by composition collar-nuts and retaining set-screws of steel. The two lower side-rods are to be fitted with composition gibs which will slide on facings projecting from the crank shaft pillow-blocks.

### CROSS-HEADS AND CROSS-TAIL.

The cross-heads are to be of wrought iron of the best quality, finished all over ; they are to have journals 10 inches in diameter and 14 inches in length, with collars at each side 14 inches in diameter, and octagonal arms extending to bosses 10 inches in diameter and 10 inches long, which are to be bored and counterbored for the piston and side-rods and nuts. The cross-tail is to be of wrought iron finished all over; it will have a central boss 17 inches in diameter, from which will spring four arms, terminating in bosses 8½ inches in diameter and 10 inches long, which are to be bored and counterbored for side-rods and nuts. The eye through the central boss, which is to be 13 inches deep, is to be bored and counterbored for the piston-rod and nuts. Each cross-head is to be mounted on a sled fitted with a composition slipper 21 inches wide by 33 inches long; the sleds to be made of cast-iron, each with two brackets, on which the cross-head rests, and secured to it by two wrought-iron bolts 2 inches in diameter in each bracket.

### BACKING-SLIDES.

The backing-slides are to be of composition, 13 inches wide, with a wearing surface of 5 inches; they are to be secured each by five bolts 1½ inch in diameter.

### CONNECTING-RODS.

The connecting-rods are to be of the best wrought iron, finished all over; the heads of crank-pins to be 15 inches wide, and those for cross-heads to be 10 inches wide. Each cap is to be secured by two malleable-steel bolts 5¼ inches in diameter, fitted with steel collar-nuts recessed into the caps and secured by steel retaining-screws. The brasses

are to be 2½ inches thick, bored and scraped to fit the journals of cross-heads and crank-pins, and fitted with adjustable liners.

CRANK-SHAFT.

The crank-shaft is to be made in three sections, each interchangeable with the others; they are to be of steel. Each section is to be forged solid with oval crank-webs 8 inches in thickness, and the greatest width 27 inches. The main journals are to be 16 inches in diameter and 27 inches long; the crank-pin journals to be 15 inches in diameter and 20 inches long; the shoulders of main journals to be 19½ inches in diameter. Each shaft will have a coupling 29 inches in diameter and 6 inches thick, forged on each end; the three sections will be secured together each by four steel key-bolts 2 inches thick by 2½ inches wide, and a steel cross-key 2 inches thick and 4 inches wide between the couplings.

CRANK-SHAFT BRASSES.

The crank-shaft brasses are to be in two parts for each journal, divided in a vertical plane; they are to be cast hollow and fitted for the circulation of water through them, and provided with the necessary pipes and valves. The metal around the bearing-faces to be 1½ inch thick, the shells and ribs ¾ inch thick. The brasses are to have faced flanges 1½ inch thick, which terminate in collars 19½ inches in diameter to match the shoulders of the journals; the brasses are to rest upon and be retained by wrought-iron key-chocks referred to below. They are to be bored in place and scraped to fit the journals.

CRANK-SHAFT PILLOW-BLOCKS.

The pillow-blocks for each crank-shaft journal are to be made with a cast-iron pedestal, and two wrought-iron caps and wrought-iron and composition key-chocks above and below the brasses, and so arranged that, with the stay-rods, the brasses may be accurately adjusted in the re-

quired direction, or readily removed. The pedestals will each have a sole-plate faced 2½ inches thick and 21 inches wide, well ribbed to central web, which is to be 2 inches thick and bounded by a flange 2 inches thick and 17 inches wide. Each pedestal will be made with an eye for the lower stay-rod, which will be covered by a wrought-iron plate faced 17 inches wide, 24 inches long, and 3½ inches thick, and secured in place to clamp the stay-rod by four wrought-iron tap-bolts 3 inches in diameter, with composition nuts. The caps are to be faced 17 inches wide and 6 inches thick; each formed with two lugs 3½ inches wide, extending across the cap and projecting 2½ inches; they will lock with the pedestal and a crown block which is made to clamp the upper stay-rod in the same manner as that for the lower one; the distance from center to center of stay-rods will be 36 inches, the length of caps 50 inches.

ECCENTRICS.

The eccentrics are to be made of cast steel in two parts, and each finished to a diameter of 43½ inches and a face of 5¼ inches, and will have a throw of 3 inches; they will be rabbeted 2¼ inches wide and 1⅛ inch deep on each side at circumference, for the flanges of straps. They will be clamped on the couplings of the crank-shaft, each by two malleable-steel bolts 2¼ inches in diameter, and also secured in place by the coupling key-bolts already referred to.

ECCENTRIC-STRAPS.

The straps are to be of composition in two parts, finished all over; they will be 2⅛ inches thick, and made with flanges to match the rabbets of the eccentrics, and with lugs for the link-bars and the clamping-bolts; they will be secured together by two malleable-steel tap-bolts 2½ inches in diameter with finished heads.

ECCENTRIC-BARS.

The eccentric-bars are to be of the best wrought-iron, recessed into and fixed to the lugs of straps by three wrought-

iron tap-bolts with finished heads; section of metal at lug of strap to be 4½ inches by 2⅛ inches; the bars are to be forked and coupled to the links by straps, gibs, keys, and brasses of the proper proportions; the length from center of eccentric to center of link to be 54 inches.

### LINKS.

The links are to be of wrought-iron, made with two bars 2 inches thick and 6 inches wide, secured together with 1½-inch stud-bolts at each end, with thimbles 2½ inches in diameter. The pins for the eccentric-bars are to be forged on and finished to 3¼ inches in diameter and 2¾ inches long, and will be 23 inches between centers.

### LINK-BLOCKS.

Each link-block will be of wrought-iron, with pin forged in and finished to a diameter of 3½ inches and a length of 3 inches; the jaws will have lips 10 inches long, projecting 2 inches; they will inclose adjustable composition gibs 12 inches long; each block will have a movement of 23 inches.

### SUSPENDING-RODS FOR MAIN-LINKS.

The suspending-rods are to be of wrought-iron, and forked to connect with both sides of the links; they will couple with the links by means of composition rings fitting concentric grooves in the bosses of the rods and links, and be adjusted to links each by a wrought-iron bolt 1¼ inch in diameter with washer and nut; the rods will be connected to rock-shaft arms in the same manner as to the links.

### VIBRATING-BEAM.

A vibrating-beam will couple the link-block with the rock shaft arm-pin and a radius-bar; it is to be formed of two straps of wrought-iron and two sets of well-proportioned gibs, keys, and brasses; the straps to be 3 inches wide and 2⅜ inches thick; the beams for working the valves to be 14½ inches between centers of block and arm-pin and 34½ inches between extreme centers of pins.

### RADIUS-BARS.

The radius-bars are to be made of wrought-iron $5\frac{5}{8}$ inches between centers for high-pressure cylinder and $7\frac{7}{8}$ inches between centers for low-pressure cylinders. They will be 2 inches thick, 4 inches wide at pin, and 5 inches wide at journal; the pins are to be $2\frac{1}{4}$ inches in diameter and 3 inches long; the journals to be 3 inches in diameter and 7 inches long. The bearings are to be fitted with brasses adjustable to the journals.

### ROCK-SHAFTS AND ARMS.

The rock-shafts for main valves are to be of steel, $8\frac{1}{2}$ inches in diameter and 8 feet 8 inches long; they will be fitted with wrought-iron arms for connecting with links and valve-stems; the link and valve-arms for high-pressure valves are to be respectively $14\frac{1}{2}$ and 12 inches between centers; the pins on link-arms to be $4\frac{1}{2}$ inches in diameter and 3 inches long; the pins on valve-arms to be $3\frac{1}{4}$ inches in diameter and 3 inches long; the section of metal in arms to be of ample proportions. The rock-shafts for cut off valves are to be of wrought-iron, made hollow, in halves, with the arms forged on one of the halves; they are to be 12 inches in outside diameter and $1\frac{1}{2}$ inch thick; they will be fitted with composition bushings and bolted together on the main rock-shaft; the pins on arms for connecting with the valve-stems to be $2\frac{3}{8}$ inches in diameter, $2\frac{1}{2}$ inches long, and 19 inches from center of shaft for high-pressure valves and $24\frac{1}{2}$ inches from center of shaft for low-pressure valves. Each shaft will connect with the eccentric-bar by means of two arms forged on a wrought-iron sleeve, which is fitted with a composition bushing to work on the main rock-shaft; the sleeve to be 12 inches in outside diameter and $1\frac{1}{4}$ inch thick. The main arm of sleeve to have a pin 4 inches in diameter and 3 inches long; the pin for the high-pressure valve to be 23 inches and those for the low to be $24\frac{1}{2}$ inches from center of sleeves.

position; the piston-rod will connect with the rock-shaft arm by means of a link. The cylinder will have steam and exhaust-ports of 2 inches area, and fitted with a slide-valve which will be operated by a floating-lever connected to a handle on the engine gallery; the exhaust to connect with the main condenser.

### AIR AND CIRCULATING-PUMP CHESTS.

The air and circulating-pump chests are to be made of cast iron. Each chest will be a separate casting and will comprise the pump-barrel and valve-chambers, and the supports for the condensers, which will include the channel-ways to and from the condensers; the circulating-pump chests will also include the troughs and guides for the low-pressure cross-head sleds; the chests for each couple will be firmly bolted together and to the condenser. Each pump-barrel will be fitted with a brass lining bored 18 inches in diameter and 42 inches long.

### VALVE-SEATS AND GUARDS.

The valve-seats and guards are to be of composition, and secured in place by composition bolts; the openings through the gratings of each seat to be not less than 125 inches in area for each air-pump and not less than 150 inches in area for each circulating-pump; the valves are to be of vulcanized carbolized rubber $\frac{3}{4}$ inch thick.

### REFLUX-VALVES.

Each circulating-pump will have a composition disc reflux-valve 9 inches in diameter, placed in the division wall of the valve-chambers and operated by a hand-wheel outside the chest.

### PUMP-PISTONS.

The pump-pistons are to be of composition, each packed with lignumvitæ and hemp, the latter adjustable by a follower secured by composition bolts.

PUMP-RODS.

The pump-rods are to be of wrought iron, covered with brass not less than $\frac{3}{16}$ inch thick; they are to be secured to pistons by composition closed nuts.

BED-PLATE FOR AIR AND CIRCULATING-PUMP ENGINES.

The bed-plate for the independent auxiliary engines for the air and circulating-pumps will be made of cast iron in two parts, and will include supports for the condensers and the trough and guides for the high-pressure cross-head sled; the two parts will be firmly secured together and to the condensers.

ENGINES FOR AIR AND CIRCULATING-PUMPS AND CONNECTIONS.

The air and circulating-pumps, one of each, will be worked in couples by a single auxiliary engine directly connected with an arm on a rock-shaft from which the pumps receive their motion. Each engine will have a suitable valve-gear operated from the main arm of rock-shaft. The cylinders of engines will be of cast iron, bored 10 inches in diameter, and fitted for a stroke of 30½ inches; the pistons will be of composition, the packing-rings of cast iron; the piston-rods will be made of wrought iron, 3 inches in diameter, and each will connect by two wrought-iron links with the main arm of rock-shaft. The links will be 3 feet 8 inches long between centers; they will be coupled to the arm and piston-rod head by two conical composition rings fitting two concentric grooves in each side of base of arm and piston-rod head and be adjusted by bolts 1⅛ inch in diameter, with countersunk nuts and steel retaining-screws. The piston-rod will extend beyond the head and run in guides fixed to the side of the pillow-block pedestals.

PUMP-CONNECTIONS.

The pumps will be connected with their respective rock-shaft arms by links fitted in the same manner as above

described for their engines. The arms for the pumps will also be fitted with corresponding links, which, when the pumps are required to be worked by the main engine, will be connected to lugs on the low-pressure piston-rods. The arms are to be of wrought iron; that for the circulating pump will have a hub 14 inches in diameter and 12 inches long for coupling the shaft together; that for the air-pump, 13 inches in diameter and to have a hub 7 inches long; and that for the steam cylinder, 14 inches in diameter and 9 inches long; they are to be bored to accurately fit the rock-shafts, upon which they will be keyed fast. The arms for air and circulating-pumps will be 35 inches long between the centers of hubs and bosses for lower links, and 45½ inches long between centers of hubs and bosses for upper links; the arms for auxiliary engine will be 33 inches long between centers.

ROCK-SHAFTS.

The rock-shafts for each couple of pumps are to be made of steel and in two sections; the leading section to be 8 inches in diameter, the other to be 7 inches in diameter; they will have journals 8 inches in diameter and not less than 12 inches long, and will work in composition bearings, resting on pillow-blocks built in the main engine-keelsons near the inner skin of the ship; the brasses will be held in place by wrought-iron caps, secured each by four bolts 2¾ inches in diameter, with composition countersunk nuts and steel retaining-screws.

STUFFING-BOXES FOR PUMPS AND AUXILIARY ENGINES.

The stuffing-boxes are to be of composition, each fitted with a gland and screw follower and adjusting worm-screws. The boxes will have an annular packing-space of ¾ inch and 10 inches deep; they will have faced flanges 3 inches wide and 1 inch thick, secured to the bonnets of pumps and covers of auxiliary steam cylinder by not less than five bolts 1 inch in diameter.

CONDENSER-CHESTS.

The condenser-chests are to be of cast iron, well ribbed throughout. The body of the chests and thickness of ribs will be 1 inch, the supporting flanges to be 2 inches thick. The flanges for tube-sheets and bonnets, exhaust and delivery-pipes to be 1⅝ inch thick. The exhaust nozzle will be 19 inches in diameter, and will have faced flanges 3 inches wide. The discharge-nozzle will be 10 by 16 inches, with faced flanges 3 inches wide.

TUBES.

Each chest will contain 4,200 drawn-brass tubes, ⅝ inch in outside diameter, of No. 18 wire-gauge thickness, and 81 inches long. The exposed condensing length to be 78 inches, and cooling surface 4,000 square feet. The tubes for each condenser will be placed athwartships, and arranged in three divisions, so that the condensing water will pass to the outboard delivery-valve through the tubes of each division; all the tubes to be thoroughly tinned inside and out. The tube-plates are to be of iron 1¼ inch thick, bored for the tubes and counterbored ⅞ inch in diameter and 1 inch deep for wooden or paper grommets, as may be approved; the tubes to be placed 1 inch between centers; the tube-plates to be secured to faced flanges 2½ inches wide, by composition bolts 1 inch in diameter placed not over 6 inches apart. Each division of tubes will be sustained by a brass supporting-plate ⅝ inch thick, placed equidistant between the tube-plates. The water chambers are to be closed with bonnets, having faced flanges 3 inches wide, and recessed panels; each bonnet to have a hand-hole 16 by 19 inches, closed by a cover with faced flanges 3 inches wide.

EXHAUST-PIPES.

The exhaust-pipes are to be of copper, 19 inches in diameter, and fitted with composition faced flanges riveted and brazed on, and not less than 3 inches wide.

### OUTBOARD-DELIVERY VALVES.

The two outboard-delivery valves are to be on the port side of the ship, between frames 43 and 44, and 50 and 51. The valve chambers will be of cast iron, and the seats, stems, stuffing-boxes, valves, etc., of composition, the latter to have rubber faces 14 inches in diameter and fitted to operate as checks. The chambers are to be fitted with nozzles 4 inches in diameter for the discharge from the bilge pumps, and are to be substantially secured over openings 14 inches in diameter through the side of the ship. The channels leading from the condensers to the outboard-deliveries are to be of composition, with an area of 160 square inches in each; they are to be rectangular in section until they pass the fore and aft bulkheads; from thence copper pipes 14 inches in diameter will connect them with the valve-chambers.

### INJECTION-VALVES.

The two main injection-valves will also be on the port side of the ship between frames 44 and 45, and 49 and 50. The valve-chambers are to be of cast iron, and the seats, stems, stuffing-boxes, and valves of composition, the latter to be 14 inches in diameter, faced with gum and fitted with screw valve-stems turning independently of the valves. There will be a nozzle 4 inches in diameter for fire-pump suction on the stand-pipe of chamber below the valve. There will be strainers covering the openings through the ship's side, and perforated with $\frac{3}{4}$-inch holes, equivalent to twice the area of the injection-pipes; the latter will be of copper, thoroughly tinned inside and out, and 14 inches in diameter.

### BILGE-INJECTIONS.

Bilge-injections, 10 inches in diameter, will be connected with the main injection-pipes, and furnished with ample strainers, easily accessible for cleaning and inspection.

### SEA-VALVES FOR PUMPS.

There are to be two receiving and discharge-valves for auxiliary pumps; one on each side of the ship, opposite the blow-valves, and the same distance from the center line of the ship. The chests are to be of cast iron, each with three branch-nozzles 4 inches in internal diameter and fitted with composition valves and seats. The valves are to be 5 inches in diameter, and fitted with brass screw-stems, stuffing-boxes, and hand-wheels, and connected to the pumps by copper pipes. The receiving-valve chambers are to have external strainers with $\frac{3}{8}$-inch holes equivalent in area to twice that of the valves. Each pump will also be provided with a bilge receiving-valve 5 inches in diameter.

### BOILER SEA-VALVES.

The chests of the two boiler blow-valves are to be of cast iron, each with three branch-nozzles $3\frac{1}{2}$ inches in diameter of openings; they are to be fitted with composition valves and seats. The valves are to be 5 inches in diameter, and fitted with brass screw-stems, stuffing-boxes, and hand-wheels. The chests are to be attached to the ship in the same manner as those of the main injection-valves. They are to be placed opposite the sea-valves for pumps, between frames 31 and 32, and 38 and 39; and 5 feet 6 inches from the center line of the vessel.

### FEED-PUMPS.

If required, two single-acting feed-pumps will be worked from a pin upon the forward coupling of the forward section of the crank-shaft; they will be fitted with safety-feeds, etc., complete, for returning the overflow to the filter.

### AUXILIARY PUMPS.

There are to be two horizontal steam-pumps, pattern to be approved, having water-pistons 7 inches in diameter, with a stroke of 12 inches, or of equivalent capacity; they are to be right or left, according to position, placed one in each fire-room, and fitted for feeding and pumping out the boilers,

also as bilge-pumps and for fire apparatus. There is to be a pump of the same size, fitted especially for the distiller. There are also to be three horizontal steam-pumps of the same pattern, having water-pistons 14 inches in diameter and 14 inches stroke, or of equivalent capacity, fitted for fire engines and bilge-pumps; they are to be right and left, and placed one on each side in the engine-room, and one in the forward fire-room.

A steam-pump of sufficient capacity is to be supplied which shall furnish a constant head of water to the seamen's water-closets, bathrooms, and wash-places if required.

### AUXILIARY CONDENSER.

All the heaters, pumps, blower-engines, steering and other small engines are to be arranged to exhaust into the atmosphere, and also into an auxiliary condenser. The condenser is to be placed above the filter, into which it will drain, and one of the pumps last mentioned is to circulate water through it.

### FEED-WATER FILTER.

There is to be a filter which will receive the drain from main cylinders and jackets, steam-pipes, the discharge from air-pumps, safety-feed valves, etc., and from the auxiliary condenser aforesaid. It will have a capacity of not less than 500 gallons, and will discharge into a separate fresh-water hot-well, connected by suitable valves to the receiving side of the feed-pumps, and fitted with a salt-water supply, so placed that the water admitted will pass through the filter, and the quantity can be seen and measured. The hot wells will be arranged so that the deficiency of feed-water may be supplied from the distilling apparatus.

### LINE-SHAFTING.

The line-shafting will be made of steel, finished 16 inches in diameter and in three sections; the forward and middle sections are to be 26 feet 7 inches long, and will have couplings 31 inches in diameter and 5 inches thick forged on them; they will be secured together with six steel bolts 2½ inches in diameter, and will be fitted with a steel

to be turned to a diameter of 58 inches and faced 6 inches, and to have a band 1 inch thick shrunk on the circumference of the fixed disc. Each hub to have a band 4 inches wide and 2 inches thick accurately fitted and shrunk on; the sliding clutch will have a circular groove 5 inches wide and 2¾ inches deep for a collar, which will be coupled to a forked lever fitted with a screw and hand-wheel for engaging and disengaging the coupling; the sliding disc will have a wrought-iron worm-gear on its circumference for meshing with the worm-screw of a turning engine, which is to be placed near the coupling.

The sliding disc will have holes near the circumference 3½ inches in diameter and about 6 inches apart, fitted with four steel pins 6 inches long for jacking the engine.

The coupling will be keyed to shaft by two steel feathers 2 by 2 inches and 21 inches long, placed opposite each other.

### FRICTION-BAND.

A spring-steel band 6 inches wide, and not less than ⅝ inch thick, will be bored to fit the circumference of the fixed disc and fitted with a screw, hand-wheel, and connection for clamping the disc and securing it in any position.

### BILGE-PUMPS.

There are to be two bilge-pumps, with a capacity of 100 gallons per minute, placed in the shaft alley, and worked from a pin on a disc geared from the line shafting. Each pump is to be fitted with receiving-pipes of cast-iron; the discharge to be connected to main outboard-delivery valve-chamber, or a special discharge-valve, by copper pipes.

All bilge receiving-pipes to be fitted with Macomb strainers, in easily accessible positions.

### LINE-SHAFT PILLOW-BLOCKS.

There are to be three pillow-blocks of cast-iron, with bearing-brasses 30 inches long; the blocks to be secured to wrought-iron pedestals built in the ship, and to the shaft-alley bulkhead. The caps will be made with ample oil-cups fitted with tubes for wicks.

THRUST-BEARING.

The block for thrust-bearing is to be of cast-iron, made hollow and fitted with pipes and cocks for circulating water through it; the cap will be made with a lug 12 inches long on each side, which will be recessed 4 inches deep into the block; it will also be fitted with oil-cups of ample capacity; the cap and block will be bored and fitted with 18 composition rings 20½ inches in diameter and 1½ inch thick; the rings to be bored to fit the shaft, and each ring divided in halves and secured from turning in the block. The block will be secured to a wrought-iron pedestal built in the ship, and fitted with keys so that it may be accurately adjusted in either direction.

STERN-PIPE.

The stern-pipe will be made of cast iron 1¾ inch thick for the lengths of the bushings, and 1½ inch thick between them, and well ribbed on the outside; the outboard end will be turned to fit the counterbore in the stern-post, and secured to it with two wrought-iron bolts 2½ inches in diameter, passing through the post and lugs on the pipe; the inboard end will be made with a flange 5 inches wide and 2¼ inches thick, by which it is to be secured to the after bulkhead by bolts 1¼ inch in diameter. The pipe will be bored 22 inches in diameter for a length of 42 inches at each end for the bushings.

BUSHINGS.

The bushings will be made in halves, of composition ⅝ inch thick, and with flanges 4 inches wide and 1¼ inch thick; they will be fitted with lignumvitæ staves 1½ inch thick, inserted in grooves, and will be secured by bolts 1½ inch in diameter.

STUFFING-BOX.

The stuffing-box will be made of composition, and will have a packing-space of 1 inch by 14 inches deep, and fitted with a follower made in two parts, with a space of 1½ inch between them, each part to be adjusted by three bolts 1¼ inch in diameter; the chamber of the stuffing-box to have a nozzle for connecting a valve of 3 inches diameter.

PROPELLER.

The propeller is to be made of steel, to have a diameter of 17 feet, a mean pitch of 20 feet, and a length of 25 inches, and to have four adjustable blades or of such design as may be approved by the Naval Advisory Board. The edges and surfaces of the blades to have all roughness smoothed off. The hub will be 27 inches in greatest diameter, tapering in both directions, 23 inches in diameter at the forward end to suit shoulder on shaft and 21 inches at after end, and will be 36 inches in length. At forward end it is to be counterbored 17¾ inches in diameter, for a length of 3 inches, to receive bushing of shaft, aft of which the bore will suit taper of shaft. There is to be a cap 1½ inch thick fitted at after end, with a central boss 1 inch thick recessed into the bore of hub.

ENGINE-ROOM.

A working-platform for the engine is to be situated between the condensers, above the high-pressure cross-head, with ways of reaching it from deck, quarters, and lower platform, and with all the connections for operating the starting-valves, throttles, relief-valves, reversing-engines, etc., convenient of access. There will be means of approach to all moving parts, arranged with proper ladders and steps, fitted wherever necessary, with brass hand-rails supported by wrought-iron columns.

INDICATORS.

The indicators are to be placed on the cylinders in a suitable and accessible position, and they, as well as the counters, are to be operated by levers, not pulleys.

PROVISIONS AGAINST TOTAL DISABLEMENT.

The following spare pipes will be furnished of copper: Two connected with the main stop-valves, so that in case of the irreparable disabling of the high-pressure engine, the steam may be conducted directly from the boilers to the low-pressure cylinders; another pipe so arranged that in case of the total failure of either low-pressure engine, the

exhaust steam may be carried from the high-pressure cylinder directly to the condenser on the same side, and the flanges, bolt-holes, etc., by which this length is to be connected, are to be so fitted that the pipe may be used either as a right or left handed pipe, according to the side upon which the casualty occurs; other pipes are to be arranged for conducting the exhaust of either low-pressure cylinder to the efficient condenser, or to the atmosphere through a hatch or ventilator in case of the break-down of one of the condensers.

All the connecting flanges, with their bolt-holes, etc., are to be fitted ready for use, and the former marked so that the above substitutions can be made with facility and certainty, and the necessary valves, sliding-sheets, blank-flanges or other appliances will be fitted and supplied for closing off connection with the disabled parts.

### FELTING AND CASING.

The cylinders, sides of valve-chests, and the steam and exhaust-pipes are to be covered with felt and cased with black walnut, bound with finished brass hoops. The steam and exhaust-pipes too small to be cased are to be covered with canvas outside the felt and the canvas painted.

### HOLDING-DOWN BOLTS.

All fixed parts of the engine are to be securely fastened by holding-down bolts of ample size.

## BOILERS AND ATTACHMENTS.

There are to be eight horizontal return-tubular boilers placed forward of the engines, four on each side of the vessel, divided into two groups by an athwartship watertight bulkhead with fire-rooms fore and aft between them.

There are to be two fixed smoke-pipes in vertical line over the keel, each connecting with an uptake common to four boilers.

The boilers are to be constructed of mild steel, in accord-

ance with test, prescribed by Naval Advisory Board, dated 18 June, 1883, and hereto appended. Seams not in contact with the fire are to be double-riveted. All the plates to be planed on the edges. The seams which are to be butt-jointed will be covered with straps of the same thickness as the plates with which they are in contact; all to be calked perfectly tight. Each boiler is to be 11 feet 8 inches in external diameter and 9 feet 9 inches long, and to have two cylindrical furnaces, 43 inches in internal diameter, projecting 6 inches from the front of boiler and extending to the back connections.

GRATE-SURFACE.

Each furnace is to have a grate 43 inches wide and 84¼ inches long, or 25 square feet in area, aggregating 400 square feet in the eight boilers.

GRATE-BARS.

Grate-bars to be double, in two lengths, ¾ inch thick at top, $\frac{5}{16}$ inch at bottom, 4 inches deep at centers, and 2 inches at ends.

TUBES.

Each boiler is to contain two hundred and twenty-two drawn brass tubes 2¾ inches in external diameter, 6 feet 11 inches in extreme length, and No. 11 wire-gauge in thickness.

SHELL.

Shell to be formed of plates ⅞ inch thick; the longitudinal joints to be butted and double-strapped, and the circular joint to be single-strapped and double-riveted on each side of seams. The shells will depart from the cylindrical form at each end on top, where they will be rounded to quadrants, through segments the greatest height of which is 22½ inches.

TUBE-SHEETS.

The front tube-sheet is to be $\frac{3}{4}$ inch, the back one $\frac{9}{16}$ inch thick; they are to be accurately drilled for two hundred and twenty-two tubes, spaced 4 inches horizontally and $3\frac{3}{4}$ inches vertically, between centers.

HEADS.

The front and back heads to be $\frac{3}{4}$ inch thick. The upper portions of the heads will be braced by rods $2\frac{1}{4}$ and 2 inches in diameter, placed 15 inches between centers vertically and 12 inches horizontally; the ends of rods to be made with jaws, and coupled to stay-plates at each end by a wrought-iron bolt 2 inches and $1\frac{7}{8}$ inch in diameter, respectively. Stay-plates to be of the best steel $\frac{7}{8}$ inch thick, and secured to boiler by angle-irons $2\frac{1}{2}$ by $2\frac{1}{2}$ inches. The stay-plates to be made with lugs from $3\frac{1}{2}$ to 5 inches in radius, leaving openings for the removal of braces.

FURNACES.

The furnaces are to be made of the very best corrugated steel $\frac{1}{2}$ inch thick, if obtainable. If not, each is to be formed of three cylindrical sections 43 inches in internal diameter, lap-welded, flanged on the ends, and riveted to each other with a welt $\frac{1}{2}$ inch thick between them. The furnaces to be single-riveted at their junctions with the front heads.

BACK CONNECTIONS.

The back connections are to be 23 inches deep; side and back plates to be of $\frac{9}{16}$ inch steel. The side and back heads to be stayed by screw stay-bolts $1\frac{1}{4}$ inch in diameter, spaced not over $6\frac{1}{2}$ inches from center to center at side and 7 inches at back.

FRONT CONNECTIONS.

The front connections and uptakes are to be made with double shells of wrought iron, built on channel-iron frames

2½ inches by 1½ inch; the inside and outside shells to be made of iron weighing, respectively, 5 pounds and 3 8/10 pounds per square foot. The space between shells to be filled with non-conducting material. The uptakes, at their connection with the smoke-pipes, to be 6 feet 6 inches in diameter.

The front connection doors are to be made of wrought iron, with double shell, and fitted with hinges and catches. Both shells ¼ inch thick, the outer one flanged 1 inch deep, the inner one 2¼ inches deep.

FURNACE-FRONTS.

Furnace-fronts to be made with a cast-iron frame covered with wrought-iron plates ⅜ inch thick, and having ample openings for furnace-doors. The outer plates to have air-holes 1¼ inch in diameter, capable of being shut off at pleasure, and the inner ones to be perforated with holes ¼ inch in diameter.

FURNACE-DOORS.

The furnace-doors to be made with wrought-iron fronts ¼ inch thick and flanged 1 inch deep; each to be fitted with a perforated wrought-iron back and with hinges and latches of wrought iron.

Behind each bridge-wall there is to be a cast-iron plate perforated with small holes, equivalent in area to 3 square inches per square foot of grate, to conduct air from the ash-pit to the back connection; the former is to be fitted with a register for regulating the supply.

ASH-PIT DOORS.

The ash-pit doors to be made of wrought iron ¼ inch thick, flanged 1 inch deep; to be well fitted to close the ash-pits, and arranged to hang by proper hooks on uptake-doors when not in use.

MAN-HOLES.

There are to be two man-holes 12 by 15 inches in the front head of each boiler in the outer spandrels above the fur-

naces, one in the lower and one in the upper spandrel between the furnaces, and one in the upper part of the shell. The last to be made within the circumferential strap $\frac{7}{8}$ inch thick and with a margin 6 inches wide around it.

SADDLES.

Each boiler is to rest on two saddles made of wrought iron and thoroughly secured to the ship. The boilers to be secured to the saddles by suitable wrought-iron straps and bolts. The bolts for straps, and which pass through the shell, are to be turned and snugly fitted in reamed holes.

SMOKE-PIPES.

The smoke-pipes are to be 60 feet in total height above the grates. They are to be 6 feet in diameter, and made of wrought-iron plates of No. 7 Birmingham gauge thickness. The pipes will be stiffened by angle-iron bands at top and bottom. Each pipe will also have a band 1 inch thick and 4 inches wide on the outside at the top. The lower part will be inclosed by a jacket 6 feet 6 inches in diameter, covered by a hood 7 feet in diameter, made of wrought-iron plates $\frac{1}{8}$ inch thick. The pipes to be made with butt-straps, eyes and stays, and supports for covers.

STEAM-DRUMS.

There are to be two steam-drums on each side, placed in the spandrels above the boilers, each to be 42 inches in diameter, and 7 feet 5 inches long. Shells to be $\frac{3}{8}$ inch thick, heads $\frac{1}{2}$ inch thick; each head to be braced by gussets or stay-rods equally divided on the shell.

SUPERHEATING-PIPES.

Superheating steam-pipes, 10 inches in diameter and made of copper, No. 5 Birmingham gauge thick, are to pass through the front connections on each side; they will be united with the steam-drums and with a central steam-pipe passing through the after fire-room; branches also to be of copper and the sections united by composition flanges.

### DRY-PIPES.

Each boiler is to have a properly perforated wrought-iron dry-pipe, closed at the internal end, thoroughly tinned, and of an internal diameter of 7 inches; the pipe to be placed as high as possible and to extend nearly the length of the boiler; the top to have holes $\frac{3}{8}$ inch in diameter drilled equally distant; their aggregate area to be double the cross-section of the pipe.

### SAFETY-VALVES.

Each boiler and superheating-pipe is to have an automatic spring safety-valve 6 inches in diameter, adjusted to a pressure of 90 pounds of steam and fitted with the proper levers. The chests, valves, and stems, to be of composition and seats of nickel. Chests to be connected with escape-pipes alongside the smoke-pipe, by branches, also of copper, and the escape-pipes to be fitted with mufflers. Separate provision is to be made for raising the safety-valves from deck if necessary.

### BOILER STOP-VALVES.

Each boiler is to have a composition stop-valve chamber combined with the safety-valve chamber, placed on the shell near the top, and united with the boiler and dry-pipe by flanges of suitable size and thickness; the chest to be not less than $\frac{5}{16}$ inch thick. The valve to be 7 inches in diameter, and fitted with a composition screw-stem, made to turn independently of the valve and to work in a composition nut supported by wrought-iron studs on the covers. The valve is to be operated by a composition hand-wheel 12 inches in diameter. Separate provision is also to be made for closing the stop-valves from deck if necessary.

The stop-valve chambers are to be connected with the steam-drums by copper pipes 7 inches in internal diameter and No. 12 Birmingham-gauge thickness; the pipes to have composition flanges of suitable diameter and thickness, properly riveted and brazed on.

INTERMEDIATE STOP-VALVES.

There is to be a stop-valve placed on each superheating-pipe; the chests are to be of cast iron, and, with the flanges, to be of ample thickness. They are to be fitted with composition valves, seats, and stems; the former to be 10 inches in diameter, and the latter to turn independently of the valves and to work in composition nuts supported by wrought-iron studs on the covers; the valves to be operated by composition hand wheels 15 inches in diameter.

MAIN STOP-VALVES.

There is to be a steam stop-valve placed on the main steam-pipe aft of the bulkhead between the fire rooms, for closing off the steam from the forward boilers; it is to be 12 inches in diameter and fitted in the same manner as the others.

The rims of hand-wheels of all large steam stop-valves are to be inclosed in asbestos covered with stitched canvas.

STEAM-PIPES.

The main steam-pipe leading to engines is to be of copper, 17 inches in diameter and of No. 3 Birmingham gauge thickness, connected with the high-pressure cylinder by means of a stop and throttle-valve; the several sections to be united to each other and the valve-chambers by composition flanges 1 inch thick, properly riveted and brazed to the pipes. All the steam-pipes, large and small, are to be heavily tinned inside and out.

The stop-valve chamber is to be of cast iron; the seats, valves, and stuffing-boxes of composition. The valve is to be 16 inches in diameter. The stem and hand-wheel are to be of composition; the latter 18 inches in diameter.

THROTTLE-VALVE.

The throttle-valve and chamber are to be of composition; the valve to be balanced and to have an area equal to that of the stop-valve; to be connected by proper rods and levers to be operated from the working-platform.

### SMALL STEAM-PIPES.

The four wing-boilers at least shall be fitted with suitable stop-valves and pipes for supplying the pumps, heaters, and all small engines with steam; and there shall also be a branch for the same purpose leading from the main steam-pipe. Two of the above boilers shall also be connected with the distilling apparatus, to supply it with steam.

### BLEEDER.

There is to be a copper pipe, with stop-valve 4 inches in diameter, leading from the steam-pipe to each condenser for bleeder.

### CHECK-VALVES.

Each boiler is to have a check feed-valve 2½ inches in diameter inclosed in a chest having two stop-valves of the same diameter, which may be closed, the one from the boiler and the other from the feed-pipe; the valve and chest to be of brass, and made with flanges of proper diameter and thickness for connecting with feed-pipes and boilers.

### BLOW-VALVES.

Each boiler is to have a bottom blow-valve of brass 2½ inches in diameter, also a surface blow-valve 2 inches in diameter; the blow-valves to be connected by suitable pipes to the sea-valves on the ship.

### FEED AND BLOW-PIPES.

The main feed and blow-pipes are to be made in sections not exceeding 12 feet in length, and to be of drawn-brass tubes 4 inches in diameter inside, and of No. 8 Birmingham gauge thickness; the branches to be of copper 2½ inches in diameter inside and No. 10 Birmingham gauge thick. The pipes to be fitted with composition elbows and flanges for uniting the sections, and to be expanded in and brazed to them; the interior of pipes to be well tinned.

WATER-GAUGES.

Each boiler is to have a combination gauge, which shall include a glass tube 18 inches in exposed length, and four cocks placed 6 inches apart, also a drip pan and pipe; the lowest cock to line with the bottom of glass tube and placed to show the level of the water at the highest heating surface.

SALINOMETER-POTS.

There are to be eight salinometer-pots fitted in such a manner as to be easily accessible.

STEAM-WHISTLE.

A large finished steam-whistle of brass is to be conveniently placed above deck, with copper pipe and cock connecting to main steam-pipe.

TEST.

Before being placed in the vessel all the boilers are to be tight under a pressure of 140 pounds to the square inch, which is to be obtained by filling the boilers quite full of water and lighting a fire in the furnaces, producing the pressure by the expansion of the water. The boilers, after completion, are to be painted outside with two coats of brown zinc paint.

FELTING.

After the boilers are in the vessel the shells and backs of the same are to be covered with felt securely sewed upon canvas, and inclosed in sheet-lead weighing 4 pounds per square foot, the joints to be soldered water-tight. The covering to be made with suitable openings over man and hand-holes, and the lead to be painted with two coats of brown zinc. Or, if required, a covering of galvanized iron with an air-space may be substituted on the approval of the Naval Advisory Board.

VENTILATORS.

Four ventilators, two 18 inches, and two 24 inches in diameter, are to be fitted, one of each in each fire-room; they will

extend below the deck to within 8 feet of the fire-room floor and be bell-mouthed at lower end. They are to have movable hoods, capable of being worked from the fire-room, and will be made of iron $\frac{3}{16}$ inch thick above deck, except the lower section, which will be $\frac{1}{4}$ inch thick; the portion below deck will be No. 11 wire-gauge thick. Two of the ventilators are to be arranged for hoisting ashes through them to the deck by means of the ash-hoisting engine or by blocks and pulleys; they are to be strengthened with six strips of bar-iron placed vertically in the interior; to have a side-door for passing the ash-buckets through, and all to admit of being closed tight when the blowers are in operation. All gear for operating ventilators to be of composition. [Provided for in hull specifications.]

ASH-HOIST.

An ash-hoisting engine of suitable dimensions and sufficient power will be fitted above the water-tight bulkhead, and arranged to remove ashes from either fire-room.

STORE AND OIL-ROOMS.

The store-rooms and oil-room are to be placed as shown on the drawings, and the former are to be suitably fitted with shelves, lockers, doors, etc., and well painted. The waste-locker is to be fitted with a water-pipe for flooding.

FLOOR-PLATES.

The fire-rooms and engine-room and their passages are to be floored with plates having corrugations and proper ledges and drain-holes; plates to be made of wrought iron if obtainable, and all easily removable.

BLOWERS.

The engine and fire rooms are to be supplied with air by means of blowers of such type as may be approved, placed in the fire-rooms, two on each side of the ship; each blower

to be capable of supplying with ease and certainty 12,000 cubic feet of air per minute under a pressure equal to one inch of water. The blowers are to be operated by suitable engines coupled directly with the spindles. They are to receive the air from the engine-room and quarters and deliver it into the main air-pipes of the ship, which are to be made with suitable arrangements to divert a proper supply of air directly to the fire-room.

### AIR-TIGHT COMPARTMENTS.

The boiler compartments are to be made sufficiently air-tight to maintain all the pressure which these blowers can furnish.

## MISCELLANEOUS ARTICLES, MATERIALS, ETC.

### OIL-CUPS.

The crank-shaft journals are each to have three large, finished brass oil-cups of approved design, with tubular wick-holders adjustable in oil-tubes. Each crank-pin journal is to have two similarly fitted large finished brass automatic oil-cups of approved design. All other engine-journals and moving parts, and especially the cross-head and cross-tail slides, are to have finished brass oil-cups of suitable size. Each cylinder and cylinder valve-chest is to have two properly finished brass grease-cocks, with globe, upper cock, and cup; those for the high-pressure cylinders are to be operated as pumps by the engine. Where necessary, sheet-brass drip-pans are to be attached.

### WATER-PIPES.

Water-pipes of copper, 3 inches in diameter, are to lead from the stern-pipe stuffing-box cock to engine-room, and to be fitted with cocks and hose attachments for the thrust and line-shaft bearings; also, branch-pipes and cocks for

all water-brasses. There will be pipes for supplying the crank-shaft journals, crank-pins, cross-head and cross-tail guides and slippers. There are to be suitable hose-pipes, with rose-sprinklers, properly attached to the sea-valves for wetting down ashes.

BRASS BOXES.

All journals and moving parts of iron are to run upon brass boxes.

HOLES THROUGH SHIP.

All holes through the ship are to be fitted water-tight, and covered by cocks or valves on the inside.

HOSE-COUPLINGS.

Couplings of naval standard, fitted for fire-hose and furnished with caps and spanners, are to be placed as permanent fixtures through water-tight bulkheads in such a manner that the doors in said bulkheads need not be opened for the passage of hose.

EYE-BOLTS.

Wrought-iron eye-bolts and traveler-bars are to be properly located and secured wherever required for lifting different parts of machinery, and particularly the covers of cylinders and valve-chests, the covers of air and circulating-pumps and their valve-chests, the condenser-bonnets, and the caps of pillow-blocks of crank-shaft and line-shaft journals.

LAMPS.

The shaft-alley, engine, fire, and store-rooms are to be furnished with large, fixed swivel-lamps, in sufficient numbers and of approved pattern, well secured to bulkheads.

PAINTING.

All engine work not finished is to be primed with two coats of brown zinc and oil; when placed in the vessel to

into vacuum spaces. All the bolt-holes to be reamed, and the body of the bolts to be finished to fit them snugly. All threads on bolts to correspond with the Navy standard. All brasses to fit loosely between collars of shafting. All cocks communicating with vacuum spaces to have bottom of shells cast in, and to have the plug packed by means of a stuffing box and follower. All nuts on moving parts and on pillow blocks to be thoroughly secured with keepers, pins, or steel set-screws. All brass boxes for journals to be properly channeled for the distribution of oil. All flanges coupled together to be faced, and edges made fair with each other. Packing for stuffing-boxes to be of such kind as may be approved. All patent fees to be paid by the builders, and no extra bills to be presented or additional compensation claimed. All materials and parts of the machinery shall be carefully weighed, and the records, certified to by the inspector, shall be reported to the Naval Advisory Board and to the Bureau of Steam Engineering.

If, after the completion of the machinery, there shall at any time be discovered in it any departure from the specifications, tending to cheapen its construction by lessening the thickness of metal, or by substituting iron for brass, or tool-finish for finish, or brass in which zinc is a large element, or by omission of finish when specified on drawings, or when usual on naval vessels, or by lessening the diameters and areas of pipes, valves, etc., the injury to the Government thus received may be estimated and determined by the Naval Advisory Board, under direction of the Secretary of the Navy, and the amount recovered from the parties of the first part, who hereby bind themselves to abide by such determination.

## Duplicate Pieces.

All duplicate pieces are to be finished, fitted, and ready for putting in place. They are to be as follows:

Two sets of carbolized gum-valves and springs for all steam-pumps.

One seat, with guards, bolts, etc., for receiving and delivery-valves of air-pumps.

...rt, with guards, bolts, etc., for receiving and deliv-
... of circulating-pumps.
... of follower-bolts and nuts for each steam piston,
for each air and circulating-pump piston.
... brasses for each main journal of the crank-

... brasses for each crank-pin.
... brasses for each cross head journal.
... brass slipper for each cross-head sled.
... set of brass gibs for lower side-rods.
One brass block for each Stephenson link.
One set of brasses for each eccentric-bar connection.
One set of brasses for the thrust-bearing.
One set of brasses for each line-shaft pillow-block.
Two crank-pin oil-cups, with all appendages.
Three main-journal oil-cups.
Two hundred tubes for condensers, packed in boxes.
One complete set of paper or kiln-dried wooden grommets, as may be approved, for tubes of one condenser, packed in tin, water tight, and with cases marked.
Four Macomb bilge-strainers.
All duplicate pieces not of brass to be painted with three coats of white lead and oil, and well lashed in tarred canvas, with name marked on the outside. Brass pieces to be painted with one coat of white lead and oil, and plainly marked for what purpose intended.

## Oil-Tanks, Cans, etc.

Four oil-tanks of iron $\frac{1}{8}$ inch thick, with an aggregate capacity of 1,800 gallons, are to be well secured in oil storeroom, with facilities for filling from deck and emptying, and strengthened by internal stays, or otherwise. Each to have a man-hole, also a brass cock 1 inch in diameter placed in the bottom, suitably connected with a pump.
Two copper oil-tanks of 10 gallons capacity each, with lids and drip-pans, to be placed permanently in the engine-room, in a convenient position, and to have a locked brass cock on each.
One iron tallow-tank of three hundred and fifty pounds capacity, with hinged man-hole plate on top.

INSTRUMENTS, TOOLS, ETC.

Five Tabor indicators of standard size; three fitted with springs graduated to a scale of 40 pounds to the inch, and two for a scale of 20 pounds to the inch, with proper attachments of finished brass, are to be furnished ready fitted. Each indicator stand-pipe is to be connected with each end of its main cylinder by pipes 1½ inch in inside diameter, having cocks of equal area of openings.

One set of instruments, with proper attachments, to be supported each in a brass case, as follows:

One Lane's improved spring steam-gauge.
One Lane's improved spring compound gauge.
One spring vacuum-gauge.
One counter, with positive motion.
Faces of gauges to be 8½ inches in diameter.

One eight-day clock, to strike in accordance with ship's time, to be placed independently of the other instruments and so as to be unaffected by the vibrations of the machinery.

One mercurial steam-gauge, attached to main steam-pipe.

Two mercurial vacuum-gauges for condensers, attached immediately to them.

Two mercurial siphon-gauges, attached to the low-pressure valve-chests, with a glass tube to indicate pressure from six to forty pounds above perfect vacuum.

Eight Lane's improved spring steam-gauges with 8½ inches face, in fire-rooms, so arranged that each boiler will have an independent connection with one gauge.

Seven thermometers, one for fresh-water reservoir and one for filter, one in each outboard delivery-pipe, one for each injection, and one for the steam-pipe, to be made permanent fixtures, with their stems and bulbs protected by brass covers.

One engine-room annunciator, with pulls, dials, finished brass plates and attachments, arranged to be operated from any parts of the deck required.

A copper speaking-tube to lead from the engine-room to each fire-room, with small gong attached.

Two complete sets of fire-irons.

Lazy bars for each boiler, fitted in place.

One set of wrenches complete, for engine, fitted to all the nuts, finished, marked with size, and placed in walnut racks. Wrenches for all nuts of bolts 2 inches in diameter and over, to be box-wrenches, and placed in convenient racks.

Twelve ash buckets, painted with three coats of brown zinc and oil.

Twelve coal buckets, painted with three coats of brown zinc and oil.

# TESTS OF STEEL FOR CRUISERS.

## INSTRUCTIONS TO INSPECTORS.

NAVY DEPARTMENT,
NAVAL ADVISORY BOARD,
*June* 18, 1883.

The following rules are prescribed in order to insure the fulfillment of the clause of the act of Congress of August 5th, 1882. "Such vessels * ; * * to be constructed of steel, of domestic manufacture, having as near as may be, a tensile strength of not less than sixty thousand pounds to the square inch, and a ductility in eight inches of not less than twenty-five per centum :"

I. All ship-plates, beams, angles, rivets, bolts, boiler-plates, and stays to be inspected and tested at the place of manufacture by a Naval Inspector of Material, and to be passed by him, subject to restrictions hereinafter mentioned, before acceptance by the ship-builders, whether Government or private, for incorporation into said vessels.

II. Every plate, beam, and angle, supplied for these vessels, to be clearly and indelibly stamped in two places, and with two separate brands: 1st. With that of the maker, which shall distinguish the name of the manufactory or company. 2d. With the regulation brand of the Naval Inspector of Material. The latter not to be stamped upon any of the above-mentioned material until it shall have passed the required inspection and tests, have been accepted by the Inspector, and have been stamped with the maker's brand.

In case of small articles passed in bulk, the above-mentioned brands shall be applied to the boxing or packing material of the objects.

No steel material to be received at the building yards for incorporation into the vessels except it bear, either upon its surface or that of its packing, both of these brands as evidence that it has passed the necessary Government inspection.

SHIP-PLATES.

III. In every lot of 20 plates test pieces to be cut from two plates taken at random; two test pieces being cut from each plate, one in the direction of the rolling, and one at right angles to it, shaped according to the annexed sketch. These test pieces shall in no case be annealed.

The test pieces to be submitted to a direct tensile stress until they break, and in a machine of approved character.

The initial stress to be as near the elastic limit as possible; which limit is to be carefully determined by the Inspector in a special series of tests. The first load to be kept in continuous action for five minutes. Additional loads to be then added at intervals of time as nearly as possible equal, and separated by half a minute; the loads to produce a strain of 5,000 pounds per square inch of original section of the test piece until the stress is about 50,000 pounds per square inch of original section, when the additional loads should be in increments not exceeding 1,000 pounds.

An observation to be made of the corresponding elongation measured upon the original length of eight inches.

The final elongation to be that obtained at rupture. The loads applied shall never be calculated from the indications of the pressure gauge if a hydraulic press be used.

CONDITIONS OF ACCEPTANCE.

In order to be accepted the average of the four test pieces must show an ultimate tensile strength of at least 60,000 pounds per square inch of original section, and a final elongation in eight inches of not less than 23 per cent.

Lots of material which show a strength greater than 60,000 pounds per square inch will be accepted, provided the ductility remains at least 23 per cent.

CASES OF FAILURE.

If the average of these four test pieces, numbered 1, 2, 3, 4 (called Test I), falls below either of the required limits, the plates from which pieces 1, 2, 3, 4 were cut shall be reected, and Test II made, consisting of pieces 5 and 6, cut from a third plate; if the mean of the results of these two falls below either of the above limits, the entire lot shall be rejected. If it be successful, Test III, or the mean of pieces 7 and 8, cut from a fourth plate, shall decide.

If in any of Tests I, II, III, any single piece shows a tensile strength less than 58,000 pounds, or a final elongation less than 21 per cent., the plate from which it was cut shall be rejected, and that test considered to have failed regardless of its average.

QUENCHING TEST.

IV. A test piece shall be cut from *each* plate, angle, or beam, and after heating to a cherry red plunged in water at a temperature of 82° Fahrenheit. Thus prepared it must be possible to bend the pieces under a press or hammer so that they shall be doubled round a curve of which the diameter is not more than one and a half times the thickness of the plates tested, without presenting any trace of cracking.

These test pieces must not have their sheared sides rounded off, the only treatment permitted being taking off the sharpness of the edges with a fine file.

ANGLES, BEAMS, BULB BARS, T-BARS, ETC.

V. In every lot of 20 angles or beams, &c., test pieces to be cut from the webs of two taken at random, one from each. These pieces to be fashioned in the same way, and to be subjected to the same tests, both tensile and quenching, and to fulfill the same requirements for acceptance as already prescribed for ship-plates.

Angle bars are to be subjected to the following additional tests: A piece cut from one bar in twenty to be opened out flat while cold under the hammer; a piece cut from another bar in the same lot shall be closed until the two sides touch, while cold; a piece from a third bar of the lot to be bent cold into a ring so that one of the sides of the angle bar shall be kept flat and the other side forming a cylinder, of which the internal diameter shall be equal to 3½ times the breadth of the side which remains flat. The angle bars submitted to these tests must show neither cracks, clifts, nor flaws.

Single T-bars to be submitted to the following tests: A piece to be cut from the end of a bar taken at random from each lot of 20, and to be bent cold into a half ring, so that the web remaining in its own plane, the cross flanges shall form a half cylinder, of which the internal diameter shall equal four times the height of the web of the T-bar.

At the end of another bar of the same lot the web to be split down its middle for a length equal three times its total depth, and a hole drilled at the end of the slit to prevent it spreading; the piece thus split to be opened out in its own plane, so as to make an angle of 45° with the rest, care to be taken that the part opened shall be kept straight, except that it must be joined to the rest of the bar by a bend of small radius.

Bulb bars are to be subjected to the same tests as those prescribed for T-bars, except that in bending one or more heats may be used.

All bars submitted to these tests must show neither cracks, clifts, nor flaws.

RIVETS.

VI. One bar from every lot of 20 of the bars from which rivets are made shall be subject to the same tensile test as that required for the plate tests. All bars not fulfilling the requirements of tensile strength and elongation required for plates to be rejected.

From every lot of 500 pounds four rivets are to be taken at random and submitted to the following tests, one rivet to be used for each test: 1st. A rivet to be flattened out cold under the hammer to a thickness of one-half its diameter without showing cracks or flaws. 2d. A rivet to be flattened out hot under the hammer to a thickness one-third its diameter without showing cracks or flaws. 3d. A rivet to be bent cold into the form of a hook with parallel sides without showing cracks or flaws. 4th. A rivet to be tested by shearing by riveting it up to two pieces of steel which are to be submitted to a tensile strain, the rivet not to shear under a stress of less than 50,000 pounds per square inch.

BOILER-PLATES.

VII. *Each* boiler-plate must be subjected to the same tests and in the manner prescribed for ship-plates. The ductility in eight inches must not be less than twenty-five per cent., and the ultimate tensile strength must not be less than 57,000 pounds and not more than 63,000 pounds, and the average at least 60,000 pounds.

The acceptance of material under these tests will not relieve the contractor from the necessity of making good any material which fails in working or may be rejected by the Inspector.

R. W. SHUFELDT,
*Rear-Admiral, U. S. Navy,*
*President Naval Advisory Board*

Approved:

WILLIAM E. CHANDLER,
*Secretary of the Navy.*

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